Offshore wind resource assessment: Comparative study between MM5 and WAsP

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1. OBJECTIVE:

- Compare two methods for the wind resource estimation over the German Bight in the North Sea: MM5 and WAsP.

  - **MM5**---input from the NCEP global model without measurement data.
  - **WAsP**---measurement data from offshore, coastal and land measurements.

2. MM5 MODEL:

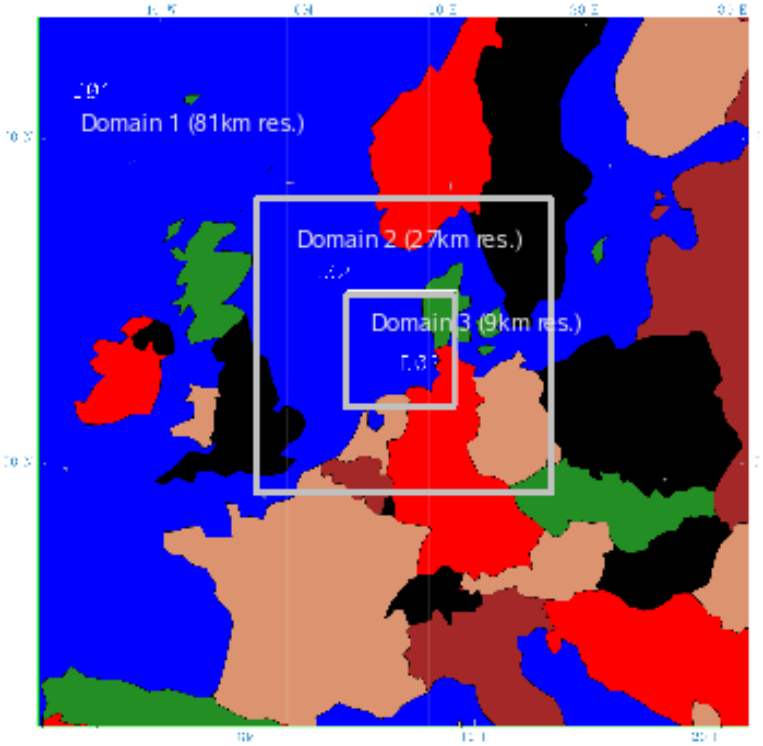
•To **simulate or predict mesoscale and regional-scale atmospheric circulation**: Resolution ranging 100 km-1 km.

•Description of **pressure, momentum and temperature**.

•Numerical solution computed onto rectangular grid by **finite difference schemes.**

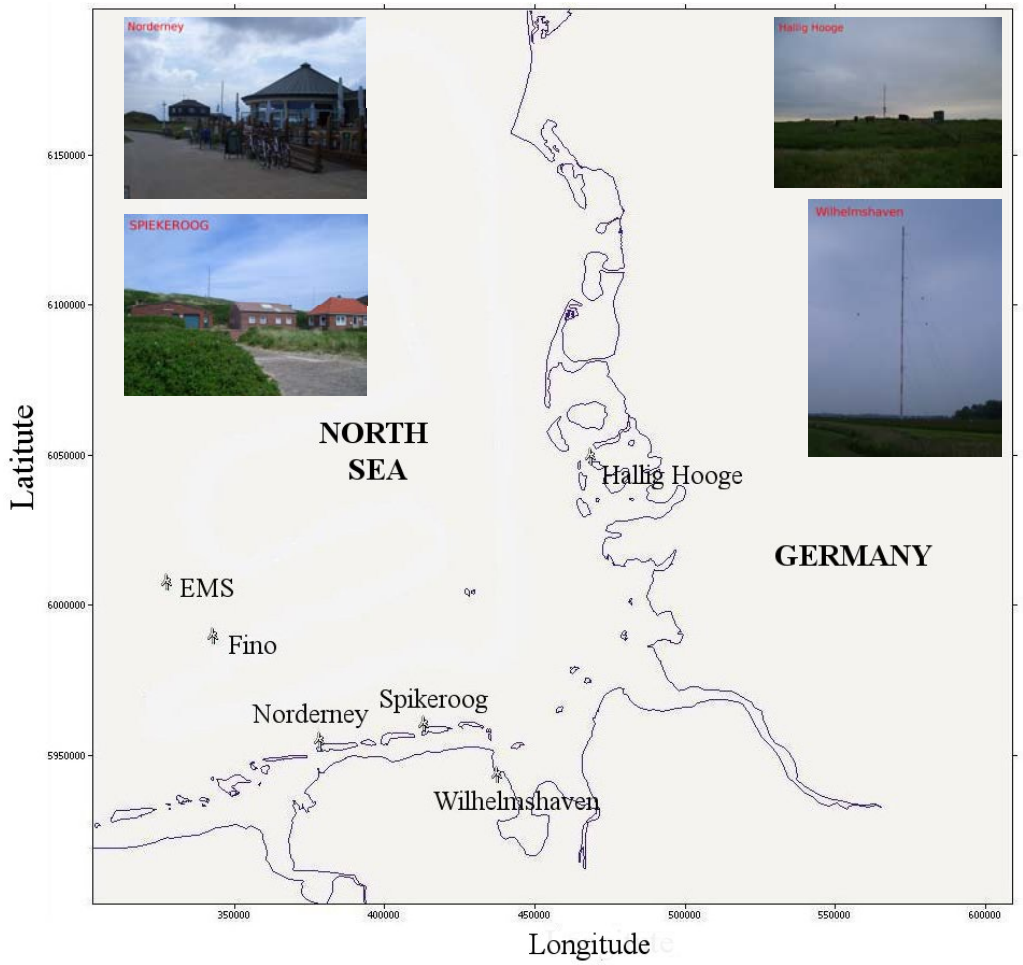
2. *MM5 MODEL: Configuration*

- Dynamics of the atmosphere of the year 2004.
- Three nested domain: 81, 27 and 9 km.
- One-way nesting.
- Simultaneous records: Measurements and MM5.



3. *WASP METHOD. MEASUREMENTS*

•WAsP estimations six stations: **land, offshore, lightship and islands.**

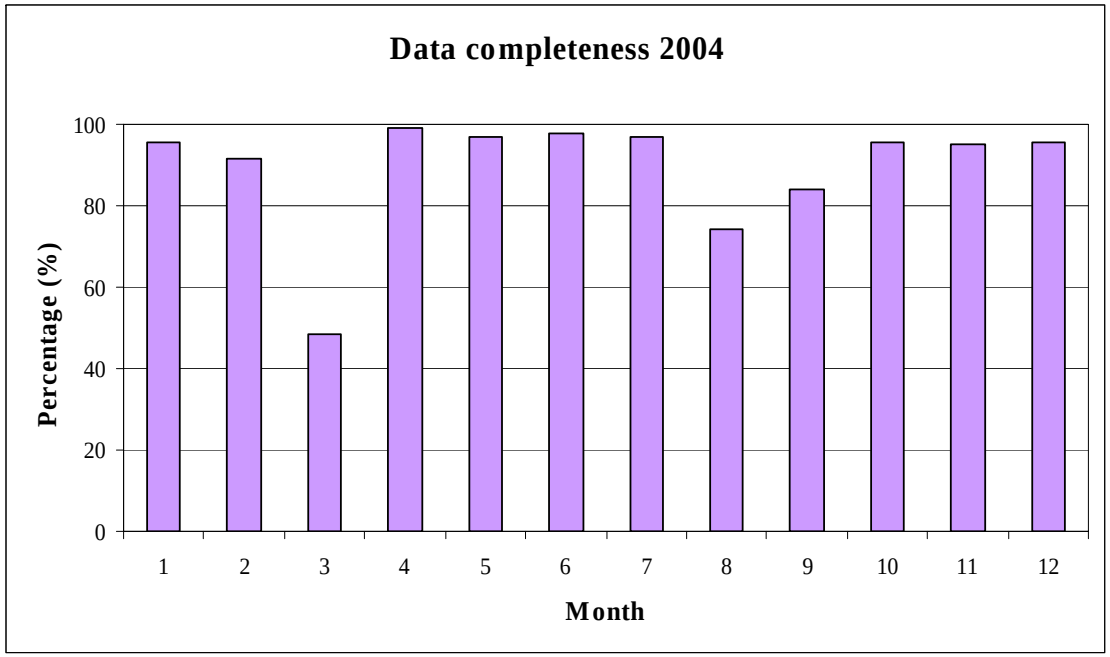


Site	Height (m)
FINO	30, 40, 50, 60, 70, 80, 90, 100*
EMS	10*
Hallig Hooge	12*
Norderney	12*
Spiekeroog	10*
WHV	32, 62*, 92, 126, 130

*Used in WAsP

3. *WASP METHOD. MEASUREMENTS*

- Data January-December 2004.
- Simultaneous time series (date and time): Data completeness.
- Data controlled by visual inspection of the time series.
- Hourly data.



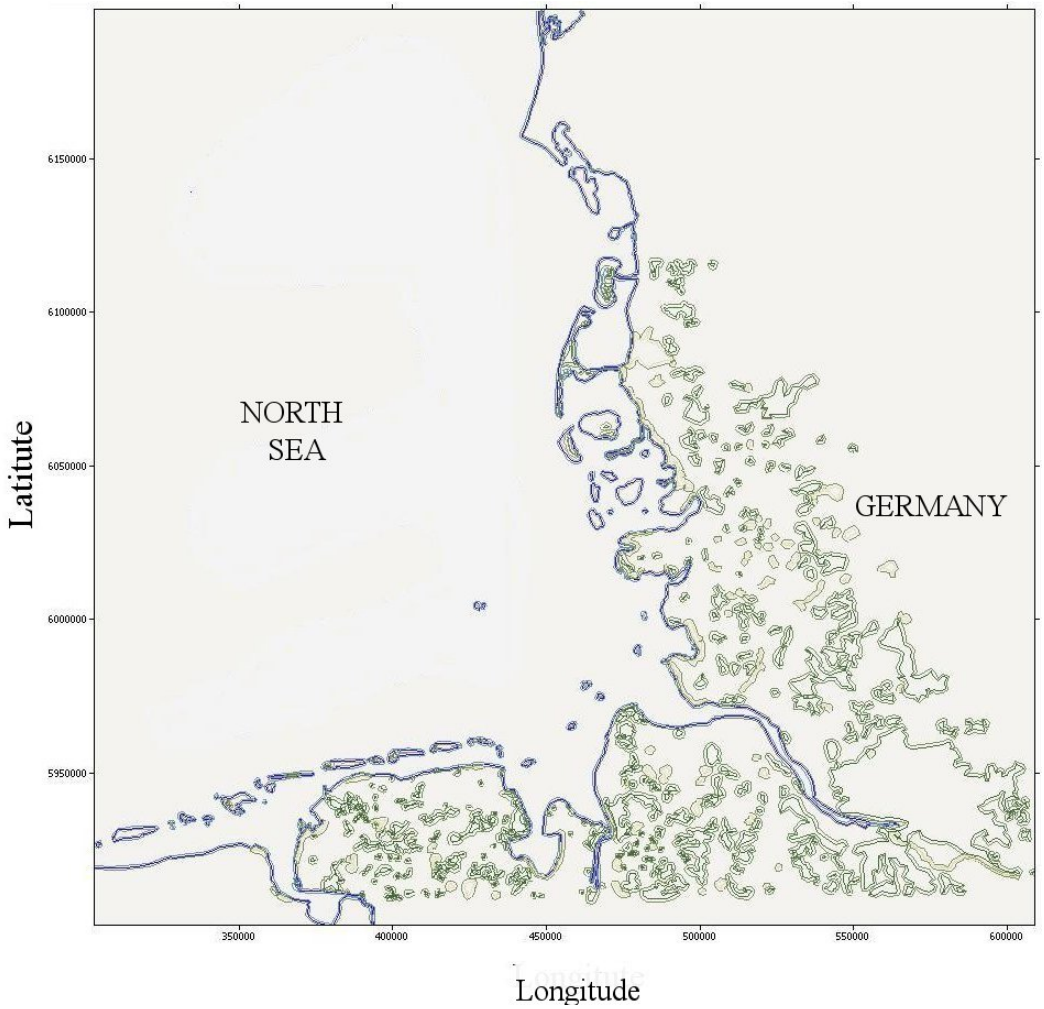
3. *WASP METHOD*

- **Corrections** for obstacles: **Norderney and Spiekeroog**

- **Correction** for the nearby wind farm: **Wilhelmshaven**

  - Orographic effects neglected (flat area).

  - **Detailed roughness description:** maps and site visit.



4. RESULTS:

Comparison:

4.1.Mean wind speed: measurements/WAsP method.

4.2.Mean wind speed at offshore sites: measurement/both models.

4.3.Wind resource maps by both models with GIS.

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- Intercomparison study.
- Height of the measurement.

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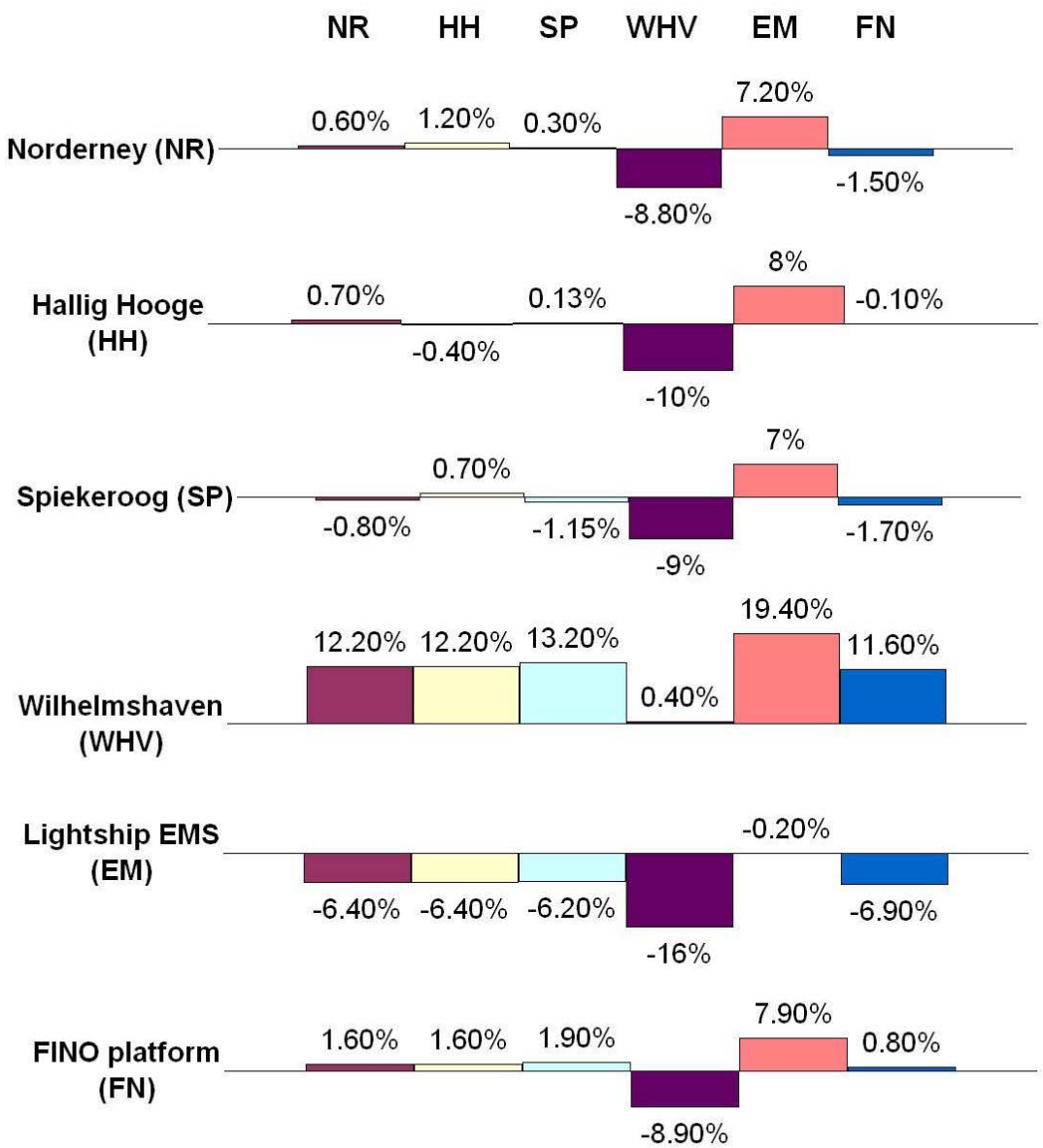
$$u_{Error}(\%) = \frac{\bar{u}_{Estimated} - \bar{u}_{Measured}}{\bar{u}_{Measured}}$$



Islands (NR, HH, SP): Small difference in their estimations (large geographical distance).

Land mast (WHV): Great differences

Offshore stations:
Underpredict (Ems)
Overpredict (FINO).

- Higher wind conditions
- Large height difference.
- Data from lightship

Well estimated island and offshore sites (island and offshore stations).

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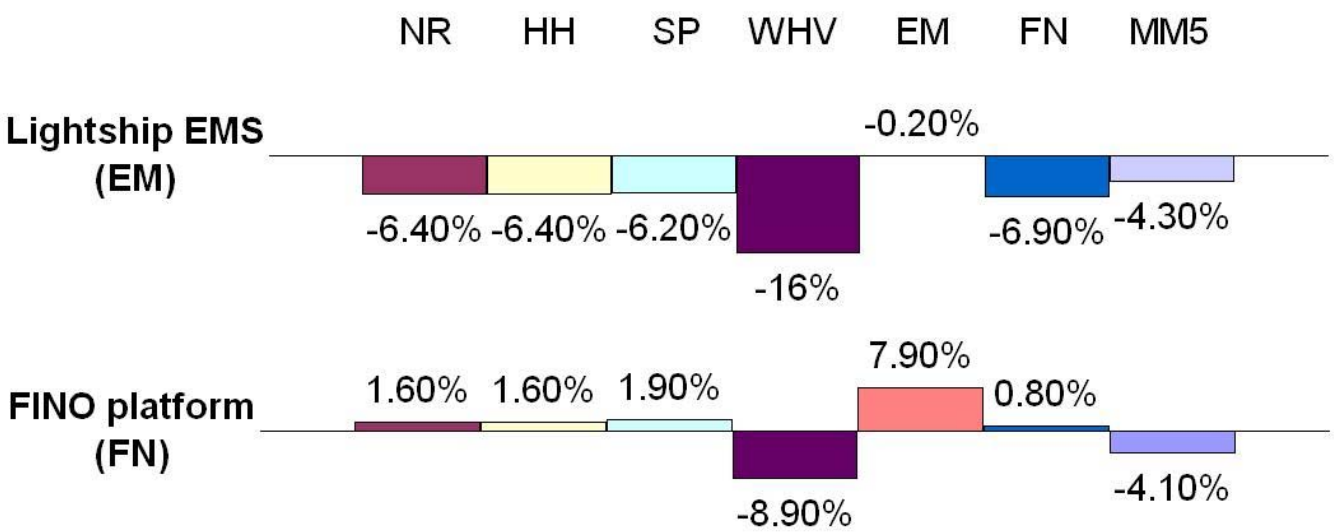
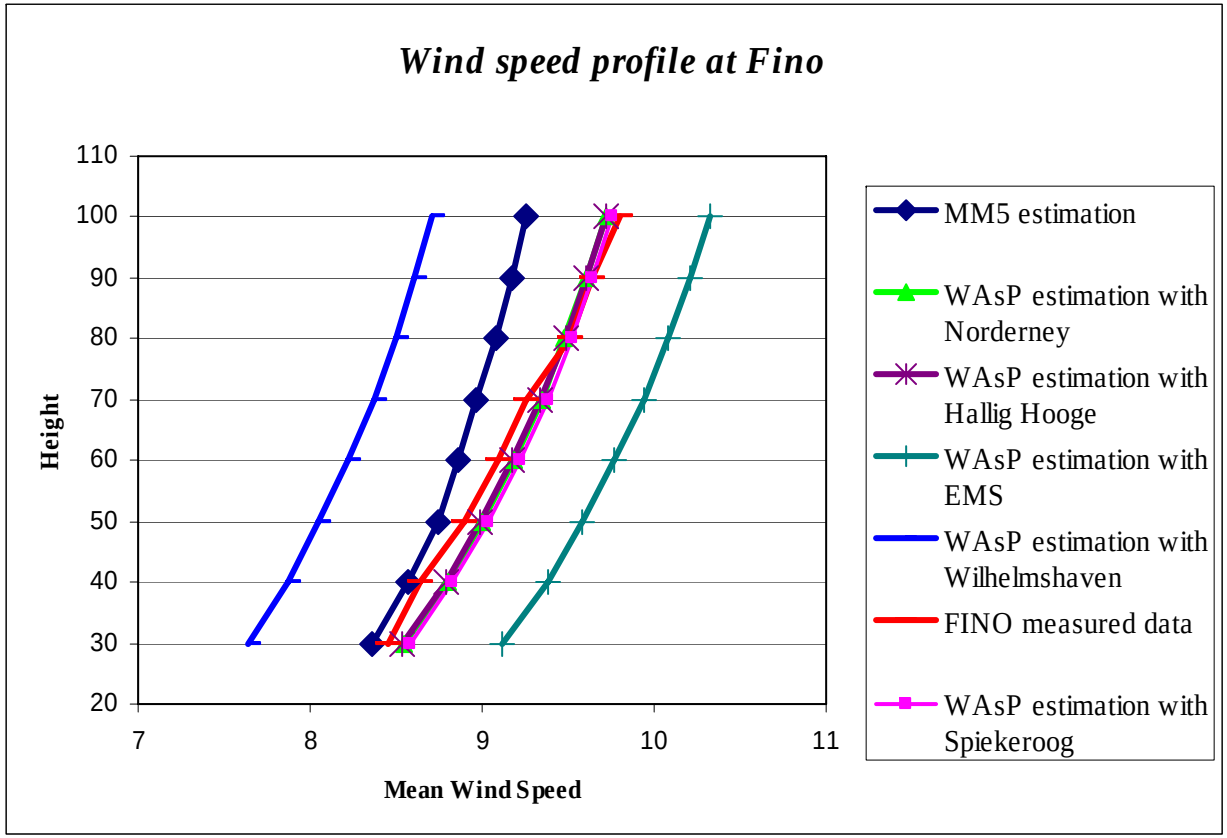


WAsP:
EMS underestimated by Fino (7%)
FINO overestimated by Ems (8%)
Three island (NR, HH, SP) similar predictions.

- Underestimate EMS (10 m).
- Overestimate FINO (100 m).

MM5: equal deviation (slightly underestimated).

Vertical wind speed profiles at FINO



- Measurement and predictions similar---MM5, WAsP (island stations).
- Great differences– WHV and EMS.

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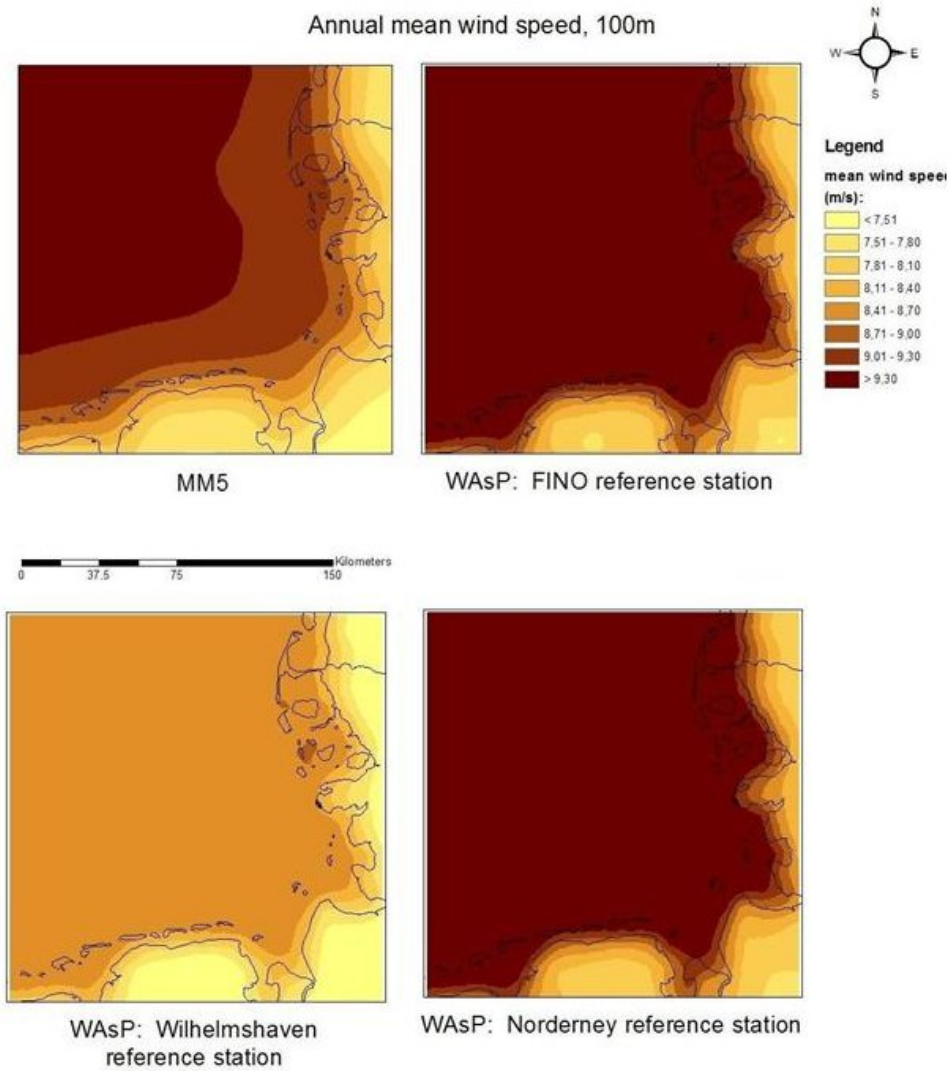
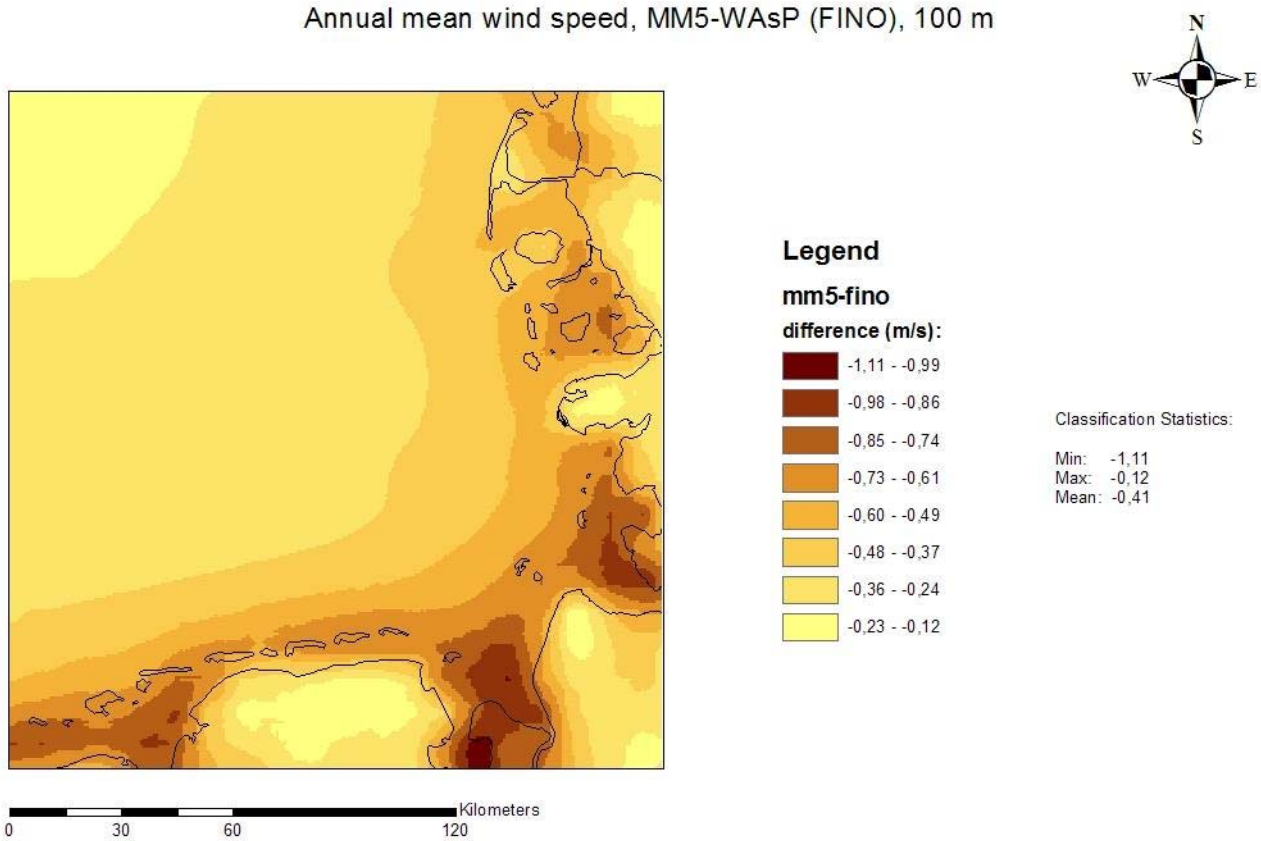
Wind resource maps with WAsP and MM5

- Grid resolution 9 km.
- 100 m height.
- Method kriging.

- WAsP:
  - Differences in function reference station.
  - Large increase first 10 km
  - No difference over the sea.

- MM5 slower increase.





Difference MM5 and WAsP:

- Particularly coastline
- Increase with decreasing distance to the coastline
- Close to the coast----decrease again.

5. CONCLUSIONS: WAsP and MEASUREMENTS

•Differences average wind speed: depend on the **measurement station used as reference**.

- **Three island stations small difference** in their estimations (large geographical distance).

- Wilhelmshaven (onshore stations) different wind conditions. Due to:
  - **Location close to the wind farm.**
  - Onshore location (!!!!!!further investigations)

5. CONCLUSIONS: MM5 and WAsP at offshore site

- **WAsP**:
  - Two offshore stations used show differences when predicting each other.
    - Height difference. Modelled differently by WAsP and MM5.
    - Lightship measurements subject to systematic errors due to flow distortion and ship movement.
  - Three island stations → agree with measurements
- **MM5** calculations same deviation for both offshore sites.

5. CONCLUSIONS: MM5 and WAsP

➢**Wind resource estimations**:

•Increase of wind speed with distance to the coast much quicker in WAsP than MM5.

•Largest differences ➡ distances 5-50 km from coast.

- •WAsP first **10 km** from the coast.
- •MM5 at least **50 km**.